PATENT ABSTRACTS OF JAPAN

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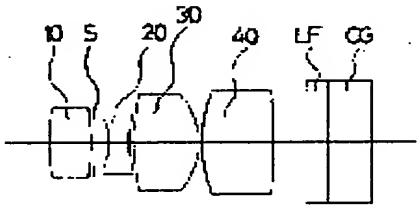
(54) PHOTOGRAPHING LENS SYSTEM

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a lens system, lens working of which is simple and inexpensive even when the image plane size is small, which is comparatively bright, and where aberration compensation is excellently performed, by constituting the system of four single lenses and making the radius of curvature of each lens large.
SOLUTION: This photographing lens system is constituted of four single lenses such as a 1st lens 10 being biconvex, a 2nd lens 20 being biconcave whose strong concave surface is faced to an object side, a 3rd lens 30 being positive whose strong convex surface is faced to an image side, and a 4th lens 40 whose strong convex surface is faced to the object side in order from the object side. It is desirable that the shaping factor of the 4th lens 40 satisfies $0.4<(r8+r7)/(r8-r7)<1.0$. Provided that r7 is the radius of curvature of the surface of the 4th lens on the object side, and r8 is the radius of curvature of the surface of the 4th lens on the image side. Thus, the photographing lens system whose half viewing angle is about 20° , which is bright with an aperture ratio such as about 1:20, where the aberration compensation is excellently performed, the lens work of which is made simple and inexpensive, and which is suitable for a camera utilizing a solid-state image pickup element is obtained.



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CLAIMS

[Claim(s)]
[Claim 1] A taking-lens system characterized by consisting of four single lenses of the 1st lens of both convexes, the 2nd lens of both concaves that turned a concave surface strong against a body side, the 3rd positive lens to which a convex strong against an image side was turned, and the 4th lens to which a convex strong against a body side was turned in order [side / body].
[Claim 2] A taking-lens system with which a shaping factor of the 4th lens is satisfied of the following conditional expression (1) in claim 1.
(1) 0.4<(r8+r7)/(r8-r7) <1.0, however r7 : Radius of curvature of a field by the side of a body of the 4th lens, r8 : Radius of curvature of a field by the side of an image of the 4th lens.
[Claim 3] A taking-lens system with which the sum of power of a field which counters mutually [the 2nd lens and the 3rd lens] is satisfied of the following conditional expression (2) in claims 1 or 2.
(2) - 1.1<phir — 4+phir5 -- < -0.1, however phir4: — field power of a field by the side of an image of the 2nd lens, and phir5: -- field power of a field by the side of a body of the 3rd lens.
[Claim 4] claim 1 thru/or any 1 term of 3 -- setting -- a field r2 by the side of an image of the 1st lens A field r7 by the side of an image of the 4th lens lens up to — a taking-lens system with which a shaft top size is satisfied of the following conditional expression (3).
(3) 1.1<sigmadi <1.7 (i=2-7)
However, di : It counts from a body side and is the shaft top gap of the i-th page and a ** (i+1) side.
[Claim 5] A taking-lens system with which a ratio of radius of curvature of both sides of the 2nd lens is satisfied of the following conditional expression (4) in claim 1 thru/or any 1 term of 4.
(4) 0.4<|r3/r4 |<1.2, however r3 : Radius of curvature of a field by the side of a body of the 2nd lens, r4 : Radius of curvature of a field by the side of an image of the 2nd lens.
[Claim 6] A taking-lens system by which ** is arranged between the 1st lens and the 2nd lens in claim 1 thru/or any 1 term of 5.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the taking-lens system suitable for the ITV camera photoed with a solid state image sensor, a video camera, an electronic "still" camera, etc.
[0002]
[Description of the Prior Art] In recent years, the so-called requests of the electronic "still" camera which records a photography image with solid state image sensors (CCD etc.) are mounting. The following properties are required compared with the photographic lens with which the taking-lens system of the camera which uses such an electric picture element uses a film.
[0003] ** Generally, since latitude is narrower than a film, an electric picture element makes aperture efficiency about 100% so that it may fully take the amount of ambient light.
** Even if it satisfies the above-mentioned **, since a fall and color gap of the amount of ambient light occur, carry out incidence of the chief ray at a perpendicularly near angle to a full screen on the structure of an electric picture element.
** It is necessary to secure arrangement spaces, such as an optical member for protection of the infrared cut-off filter for amending the optical low pass filter for moire removal, and spectral sensitivity, or an image formation side, and protection against dust, and require a long back focus between a lens and an image formation side.
[0004] Taking-lens systems, such as ** JP,49-53036,A, ** JP,57-164708,A, and ** JP,7-95141,B, are already proposed for such the purpose. However, the half-field angle of ** is as narrow as 16.5 degrees, the aperture ratio of ** is dark at about 1:4.3, and ** is an aperture ratio 1:2.8 in the half-field angle of 19.5 degrees, and moreover, since both ** - ** of the radius of curvature of the minimum refracting interface are as small as less than [the one half degree of a focal distance, or it], it has the trouble that lens processing becomes difficult and a manufacturing cost becomes high, so that a screen size becomes small.
[0005]
[Objects of the Invention] With the half-field angle of about 20 degrees, this invention is as bright as about 1:2.0 aperture ratio, and moreover, its aberration amendment is good and it aims at obtaining the taking-lens system suitable for the camera using a solid state image sensor which is simple for lens processing and can do it cheaply. Even if the radius of curvature of each lens is comparatively large and a screen size becomes small especially, lens processing aims at obtaining an easy taking-lens system.
[0006]
[Summary of the Invention] The image pick-up lens system of this invention is characterized by consisting of four single lenses of the 1st lens of both convexes, the 2nd lens of both the concaves that turned the concave surface strong against a body side, the 3rd positive lens to which the convex strong against an image side was turned, and the 4th lens to which the convex strong against a body side was turned in order from the body side.
[0007] As for the taking-lens system of this invention, it is desirable that the shaping factor of the 4th lens satisfies conditional expression (1).

(1) 0.4<(r8+r7)/(r8−r7) <1.0, however r7 : The radius of curvature of the field by the side of the body of the 4th lens, and r8 : the radius of curvature of the field by the side of the image of the 4th lens — it comes out.
[0008] Furthermore, it is desirable that the sum of the power of the field which counters mutually [the 2nd lens and the 3rd lens] satisfies conditional expression (2).
(2) − 1.1<phir — 4+phir5 — < −0.1, however phir4: — the field power of the field by the side of the image of the 2nd lens, and phir5: — the field power of the field by the side of the body of the 3rd lens — it comes out.
[0009] moreover, field r2 by the side of the image of the 1st lens Field r7 by the side of the image of the 4th lens lens up to — it is desirable that a shaft top size satisfies conditional expression (3).
(3) 1.1<sigmadi <1.7 (i=2−7)
however, di : from a body side — counting — the shaft top gap of the i−th page and a ** (i+1) side — it comes out.
[0010] As for the radius of curvature of both sides of the 2nd lens, it is desirable to satisfy conditional expression (4).
(4) 0.4<|r3/r4 |<1.2, however r3 : The radius of curvature of the field by the side of the body of the 2nd lens, and r4 : the radius of curvature of the field by the side of the image of the 2nd lens — it comes out. ** is arranged between the 1st lens and the 2nd lens.
[0011]
[Embodiment of the Invention] The 2nd lens of both concaves to which the taking−lens system of this invention turned the concave surface stronger against a 1st lens [of both convexes], and body side in order than a body side, Constitute from four single lenses of the 3rd positive lens to which the convex strong against an image side was turned, and the 4th lens to which the convex strong against a body side was turned, and the radius of curvature of each lens is enlarged comparatively. Even if a screen size becomes small, as brightly [lens processing is easy, and can do it cheaply, and] as about 1:2.0 aperture ratio, aberration amendment is good and obtains the taking−lens system suitable for the camera which moreover used the fixed image sensor.
[0012] Conditional expression (1) is conditions required in order to make it most a tele cent rucksack about 5 degrees or less about the shaping factor of the 4th lens by the side of an image. If the minimum of conditional expression (1) is exceeded, a tele cent rucksack angle (incident angle of the chief ray outside a shaft which carries out incidence to an image formation side) will be subtracted (it inclining inside) too much. When a maximum is exceeded, a tele cent rucksack angle becomes 5 degrees or more, and it becomes impossible to attain the purpose of this invention.
[0013] Conditional expression (2) is the conditions for expressing the range of the sum of the power of the field of the air lens constituted by between the opposed faces of the 2nd lens and the 3rd lens, suppressing generating of coma flare, and balancing the image surface. If negative power becomes strong exceeding a minimum, coma flare with bottom light will occur greatly outside, and it will become superfluous a curvature's of field amending it. a maximum — exceeding — negative power — if it becomes weak, since coma flare with bottom light will occur greatly inside and it will become insufficient a curvature's of field amending it, it becomes impossible to maintain the image formation engine performance
[0014] Conditional expression (3) is conditions required in order to specify the range of the gap of the 1st lens with which ****** is arranged, and the 2nd lens, and the sum total of the shaft top size from the 2nd lens to the 4th lens, to be about 5 degrees or less and to carry out incidence of the chief ray outside a shaft to an image formation side (image pick−up side). Therefore, if a shaft top size becomes short exceeding the minimum of conditional expression (4), since it will become impossible to suppress the incident angle of the chief ray outside a shaft which carries out incidence to an image formation side at about 5 degrees or less and the KOBA thickness of the 3rd lens and the 4th lens will become thin at coincidence, when especially a screen size is small, processing of a lens and assembly become difficult. If this shaft top size becomes long exceeding a maximum, a back focus will become short and arrangement of optical

members, such as a low pass filter and an infrared cut-off filter, will become difficult.
[0015] Conditional expression (4) is the conditions for amending spherical aberration and comatic aberration good about the range of the ratio of the radius of curvature of the field of the both sides of the 2nd lens which is the only negative lens among the lens whole system. Refracting interface r3 by the side of the body of the 2nd lens Radius of curvature becomes small or it is the refracting interface r4 by the side of an image. If radius of curvature becomes large and exceeds the minimum of conditional expression, amendment of superfluous spherical aberration will become impossible and an inner direction coma will occur greatly. Conversely, r3 It becomes large or is r4. If it becomes small and the maximum of conditional expression is exceeded, it will become insufficient amending spherical aberration, a method coma of outside will occur, and the good image formation engine performance will no longer be obtained.
[0016] Hereafter, this invention is explained about a concrete numerical example. Each of following example 1 thru/or 6 is order from the 1st lens 10 of both convexes, **S, the 2nd lens 20 of both concaves, the 3rd positive lens 30, and the 4th lens 40 of both convexes from the body side. The 3rd lens consisted of a biconvex lens except for the example 2 which consists of a meniscus lens, and is all equipped with the convex strong against an image side. Behind the 4th lens, in an example 1 thru/or the example 4, the cover glass CG of a low pass filter and an image sensor is arranged, and the cover glass CG of an image sensor is arranged in the example 5 and the example 6. The field by the side of the image of cover glass CG is an image pick-up side.
[0017] [Example 1] drawing 1 and drawing 2 show the 1st example of the taking-lens system of this invention, drawing 1 is the lens block diagram, and drawing 2 is many of the aberration drawings. The concrete numeric data of this lens system is shown in a table 1. The chromatic aberration [in / SA among many aberration drawings, and / in SC / sine condition, d line, g line, C line, and each wavelength] shown according to spherical aberration and S show sagittal one, and M shows MERIDIONARU. [spherical aberration]
[0018] The inside of a table and a drawing, and FNO The f number and F A focal distance and W A half-field angle and fB express a back focus. R is radius of curvature and D is lens thickness or a lens gap, and Nd. The refractive index of d line and nu show the Abbe number of d line. A back focus fB is the air scaled distance of the distance from the 4th lens last side (r8 page) to the image side (an image pick-up side and r11) of cover glass CG (fB=d8+(d9/N9)+ (d10/N10)).
[0019]
[A table 1]
FNO=1:2.1 F=5.24W=20.1fB=3.44 Field No. R D Nd nud 1 10.330 1.83 1.84666 23.9 2 - 10.330 0.12 - - ** infinity 0.62 - - 3 - 3.894 0.91 1.92286 21.3 4 7.056 0.17- - 5 12.2682.76 1.72916 54.7 6- 4.000 0.15 - - 78.372 3.131.72916 54.7 8 - 29.0581.42 -- 9 infinity 0.99 1.45854 68.0 10infinity 2.00 1.49176 57.4 11 infinity - - - [0020] [Example 2] drawing 3 and drawing 4 show the 2nd example of the taking-lens system of this invention, and drawing 3 is [many aberration drawings and the table 2 of a lens block diagram and drawing 4] concrete numeric data.
[0021]
[A table 2]
FNO=1:2.0 F=5.24W=19.6fB=2.46 Field No. R D Nd nud 1 5.577 2.04 1.83400 37.2 2 - 20.675 0.14 - - ** infinity 0.89 - - 3 - 4.744 0.80 1.9228621.3 4 6.230 0.59- - 5-19.000 1.93 1.7410052.76 - 3.673 0.20 - - 7 5.310 2.14 1.74100 52.78 - 31.021 0.44 -- 9 infinity 0.99 1.45854 68.0 10 infinity 2.00 1.49176 57.4 11 infinity - - - [0022] [Example 3] drawing 5 and drawing 6 show the 3rd example of the taking-lens system of this invention, and drawing 5 is [many aberration drawings and the table 3 of a lens block diagram and drawing 6] concrete numeric data.
[0023]
[A table 3]
FNO=1:2.0 F=5.24W=20.3fB=3.02 Field No. R D Nd nud 1 11.539 4.30 1.80518 25.4 2 - 14.624 0.19 - - ** infinity 0.64 - - 3 - 4.541 0.80 1.7508427.7 4 4.685 0.11- - 5 6.341 2.53 1.56873 63.1 6- 3.483 0.15 - - 7 5.403 2.401.56873 63.1 8 - 14.8131.00 -- 9 infinity 0.99 1.45854 68.0 10 infinity 2.00 1.49176 57.4 11 infinity - - - [0024] [Example 4] drawing 7 and drawing 8 show the 4th example of the taking-lens system of this invention, and drawing 7 is [many aberration drawings and the table 4 of a lens block diagram and drawing 8] concrete numeric data.

[0025]
[A table 4]
FNO=1:2.0 F=5.24W=20.1fB=3.07 Field No. R D Nd nud 1 10.549 4.05 1.80518 25.4 2 - 18.466 0.44 - - ** infinity 0.69 - - 3 - 4.004 0.80 1.9228620.9 4 6.993 0.12- - 5 10.6732.44 1.80400 46.6 6- 3.945 0.15 - - 7 5.672 2.321.69349 50.8 8 - 319.677 1.05 - - 9 Infinity0.99 1.45854 68.0 10 Infinity 2.00 1.49176 57.4 11 Infinity - - -[0026] [Example 5] drawing 9 and drawing 10 show the 5th example of the taking-lens system of this invention, and drawing 9 is [many aberration drawings and the table 5 of a lens block diagram and drawing 10] concrete numeric data.
[0027]
[A table 5]
FNO=1:2.0 F=5.24W=20.1fB=1.35 Field No. R D Nd nud 1 8.869 4.18 1.80740 35.4 2 - 15.222 0.18 - - ** infinity 0.63 - - 3 - 4.228 0.80 1.7847026.2 4 4.895 0.12- - 5 6.6352.36 1.64000 60.1 6- 3.531 0.15 - - 7 5.147 4.071.64000 60.1 8 -100.000 0.69 - - 9 infinity1.00 1.51633 64.1 10 infinity - - - [0028] [Example 6] drawing 11 and drawing 12 show the 6th example of the taking-lens system of this invention, and drawing 11 is [many aberration drawings and the table 6 of a lens block diagram and drawing 12] concrete numeric data.
[0029]
[A table 6]
FNO=1:2.0 F=5.24W=20.1fB=2.55 Field No. R D Nd nud 1 11.095 4.21 1.83400 37.2 2 - 20.772 0.59 - - ** infinity 0.53 - - 3 - 4.069 0.80 1.6989530.1 4 4.452 0.07- - 5 5.537 2.44 1.61800 63.4 6- 3.671 0.15 - - 75.496 2.641.61800 63.4 8 -19.3861.89 -- 9 infinity 1.00 1.51633 64.1 10 infinity - - - [0030] Next, the value over an example 1 thru/or the monograph affair type of 6 is shown in a table 7.
[A table 7]

	実施例1	実施例2	実施例3
条件式(1)	0.5527	0.7077	0.4655
条件式(2)	-0.3739	-0.9804	-0.3699
条件式(3)	1.5000	1.2770	1.3015
条件式(4)	0.5519	0.7615	0.9693

	実施例4	実施例5	実施例6
条件式(1)	0.9651	0.9021	0.5582
条件式(2)	-0.2968	-0.3346	-0.2378
条件式(3)	1.3273	1.5853	1.3802
条件式(4)	0.5726	0.8637	0.9140

[0031] The numeric value of an example 1 thru/or an example 6 has satisfied conditional expression (1) thru/or (4) so that clearly from a table 7. Moreover, each aberration is also amended good so that clearly from aberration drawing.
[0032]
[Effect of the Invention] According to this invention, with the half-field angle of about 20 degrees, it is as bright as about 1:2.0 aperture ratio, and moreover, aberration amendment is good and can obtain the taking-lens system suitable for the camera using a solid state image sensor easy [lens] and made cheaply.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the lens block diagram of the 1st example of the taking-lens system by this invention.
[Drawing 2] They are many aberration drawings of the lens system of drawing 1 .
[Drawing 3] It is the lens block diagram of the 2nd example of the taking-lens system by this invention.
[Drawing 4] They are many aberration drawings of the lens system of drawing 3 .
[Drawing 5] It is the lens block diagram of the 3rd example of the taking-lens system by this invention.
[Drawing 6] They are many aberration drawings of the lens system of drawing 5 .
[Drawing 7] It is the lens block diagram of the 4th example of the taking-lens system by this invention.
[Drawing 8] They are many aberration drawings of the lens system of drawing 7 .
[Drawing 9] It is the lens block diagram of the 5th example of the taking-lens system by this invention.
[Drawing 10] They are many aberration drawings of the lens system of drawing 9 .
[Drawing 11] It is the lens block diagram of the 6th example of the taking-lens system by this invention.
[Drawing 12] They are many aberration drawings of the lens system of drawing 11 .
[Description of Notations]
10 1st Lens
20 2nd Lens
30 3rd Lens
40 4th Lens
S **
LF Low pass filter
CG Cover glass

[Translation done.]

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審査請求　未請求　請求項の数６　ＯＬ　（全 10 頁）

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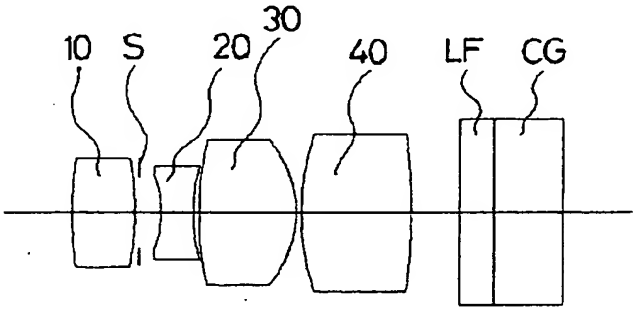
(54)【発明の名称】　撮影レンズ系

(57)【要約】

【目的】　半画角２０°程度で、口径比１：２．０程度と明るく、しかも収差補正が良好で、レンズ加工が簡単で安価にできる、固体撮像素子を利用したカメラに適した撮影レンズ系を得る。

【構成】　物体側より順に、両凸の第１レンズと、物体側に強い凹面を向けた両凹の第２レンズと、像側に強い凸面を向けた正の第３レンズと、物体側に強い凸面を向けた第４レンズとの単レンズ４枚からなる撮影レンズ系。



【特許請求の範囲】

【請求項１】　物体側より順に、両凸の第１レンズと、物体側に強い凹面を向けた両凹の第２レンズと、像側に強い凸面を向けた正の第３レンズと、物体側に強い凸面を向けた第４レンズとの４枚の単レンズからなることを

$$（1）\ 0．4＜（r_8＋r_7）／（r_8－r_7）＜1．0$$

但し、

r_7 ：第４レンズの物体側の面の曲率半径、

r_8 ：第４レンズの像側の面の曲率半径。

【請求項３】　請求項１または２において、第２レンズと第３レンズの互いに対向する面のパワーの和が下記条件式（２）を満足する撮影レンズ系。

$$（2）\ -1．1＜\phi_{r4}+\phi_{r5}＜-0．1$$

但し、

ϕ_{r4}：第２レンズの像側の面の面パワー、

ϕ_{r5}：第３レンズの物体側の面の面パワー。

【請求項４】　請求項１ないし３のいずれか１項において、第１レンズの像側の面r_2より、第４レンズレンズの像側の面r_7までの軸上寸法が、下記条件式（３）を満足する撮影レンズ系。

$$（3）\ 1．1＜\Sigma d_i＜1．7\quad（i＝2～7）$$

但し、

d_i ：物体側から数えて第ｉ面と第（ｉ＋１）面の軸上間隔。

【請求項５】　請求項１ないし４のいずれか１項において、第２レンズの両面の曲率半径の比が、下記条件式（４）を満足する撮影レンズ系。

$$（4）\ 0．4＜|r_3／r_4|＜1．2$$

但し、

r_3 ：第２レンズの物体側の面の曲率半径、

r_4 ：第２レンズの像側の面の曲率半径。

【請求項６】　請求項１ないし５のいずれか１項において、第１レンズと第２レンズの間には、絞が配置されている撮影レンズ系。

【発明の詳細な説明】

【０００１】

【技術分野】本発明は、固体撮像素子で撮影するＩＴＶカメラ、ビデオカメラ、電子スチルカメラ等に適した撮影レンズ系に関する。

【０００２】

【従来技術及びその問題点】近年、固体撮像素子（ＣＣＤ等）で撮影画像を記録するいわゆる電子スチルカメラ等の要望が高まっている。このような電気的画像素子を使用するカメラの撮影レンズ系は、フィルムを使用する写真レンズに比べて、次のような特性が要求される。

$$（1）\ 0．4＜（r_8＋r_7）／（r_8－r_7）＜1．0$$

但し、

r_7 ：第４レンズの物体側の面の曲率半径、

r_8 ：第４レンズの像側の面の曲率半径、

である。

特徴とする撮影レンズ系。

【請求項２】　請求項１において、第４レンズのシェイピングファクターが下記条件式（１）を満足する撮影レンズ系。

$$（1）\ 0．4＜（r_8＋r_7）／（r_8－r_7）＜1．0$$

【０００３】①電気的画像素子は一般的にフィルムよりラチチュードが狭いため、周辺光量を充分にとるべく開口効率をほぼ１００％にする。

②上記①を満足しても、電気的画像素子の構造上、周辺光量の低下や色ズレが発生するため、主光線を全画面に対して垂直に近い角度で入射させる。

③レンズと結像面の間に、モアレ除去のための光学的ローパスフィルター、分光感度を補正するための赤外カットフィルター、あるいは結像面の保護と防塵のための光学部材等の配置スペースを確保する必要があり、長いバックフォーカスを要する。

【０００４】このような目的で既に、①特開昭４９－５３０３６号公報、②特開昭５７－１６４７０８号公報、③特公平７－９５１４１号公報等の撮影レンズ系が提案されている。しかし、①は半画角が１６．５°と狭く、②は口径比が１：４．３程度で暗く、③は半画角１９．５°で口径比１：２．８であり、しかも、①～③のいずれも、最小の屈折面の曲率半径は焦点距離の半分程度またはそれ以下と小さいため、画面サイズが小さくなる程レンズ加工が困難になり製造コストが高くなるという問題点がある。

【０００５】

【発明の目的】本発明は、半画角２０°程度で、口径比１：２．０程度と明るく、しかも収差補正が良好で、レンズ加工が簡単で安価にできる、固体撮像素子を利用したカメラに適した撮影レンズ系を得ることを目的とする。特に、各レンズの曲率半径が比較的大きく、画面サイズが小さくなっても、レンズ加工が容易な撮影レンズ系を得ることを目的とする。

【０００６】

【発明の概要】本発明の撮像レンズ系は、物体側より順に、両凸の第１レンズと、物体側に強い凹面を向けた両凹の第２レンズと、像側に強い凸面を向けた正の第３レンズと、物体側に強い凸面を向けた第４レンズとの４枚の単レンズからなることを特徴としている。

【０００７】本発明の撮影レンズ系は、その第４レンズのシェイピングファクターが、条件式（１）を満足することが好ましい。

【０００８】さらに、第２レンズと第３レンズの互いに対向する面のパワーの和が、条件式（２）を満足することが好ましい。

$$（2）\ -1．1＜\phi_{r4}+\phi_{r5}＜-0．1$$

但し、
ϕ_{r4}：第２レンズの像側の面の面パワー、
ϕ_{r5}：第３レンズの物体側の面の面パワー、
である。

【０００９】また、第１レンズの像側の面r_2より、第４レンズレンズの像側の面r_7までの軸上寸法が、条件式（３）を満足することが好ましい。

（３）$1.1 < \Sigma d_i < 1.7$　（ｉ＝２～７）

但し、
d_i：物体側から数えて第ｉ面と第（ｉ＋１）面の軸上間隔、
である。

【００１０】第２レンズの両面の曲率半径は、条件式（４）を満足することが好ましい。

（４）$0.4 < |r_3 / r_4| < 1.2$

但し、
r_3：第２レンズの物体側の面の曲率半径、
r_4：第２レンズの像側の面の曲率半径、
である。絞は、第１レンズと第２レンズの間に配置する。

【００１１】

【発明の実施の形態】本発明の撮影レンズ系は、物体側より順に、両凸の第１レンズと、物体側に強い凹面を向けた両凹の第２レンズと、像側に強い凸面を向けた正の第３レンズと、物体側に強い凸面を向けた第４レンズとの４枚の単レンズから構成し、比較的各レンズの曲率半径を大きくして、画面サイズが小さくなってもレンズ加工が簡単で安価にでき、かつ口径比１：２．０程度と明るく収差補正が良好で、しかも固定撮像素子を利用したカメラに適した撮影レンズ系を得たものである。

【００１２】条件式（１）は、最も像側の第４レンズのシェイピングファクターに関するもので、５°程度以下のテレセントリックにするために必要な条件である。条件式（１）の下限を越えると、テレセントリック角（結像面に入射する軸外主光線の入射角）がマイナス（内側に傾く）になり過ぎる。上限を越えると、テレセントリック角が５°以上となり本発明の目的が達成できなくなる。

【００１３】条件式（２）は、第２レンズと第３レンズの対向面間によって構成される空気レンズの面のパワーの和の範囲を表し、コマフレアーの発生を抑え、像面のバランスをとるための条件である。下限を越えて負のパワーが強くなると、下光線によるコマフレアーが外側に大きく発生し、像面湾曲が補正過剰となる。上限を越えて負のパワー弱くなると、下光線によるコマフレアーが内側に大きく発生し、像面湾曲が補正不足となるので、結像性能が保てなくなる。

【００１４】条件式（３）は、開放絞が配置される第１レンズと第２レンズの間隔と第２レンズから第４レンズまでの軸上寸法の合計の範囲を規定するもので、軸外主光線を結像面（撮像面）に対して５°程度以下で入射させるために必要な条件である。したがって条件式（４）の下限を越えて軸上寸法が短くなると、結像面に入射する軸外主光線の入射角を５°程度以下に抑えることができなくなり、同時に第３レンズ及び第４レンズのコバ厚が薄くなるので、特に画面サイズが小さい場合に、レンズの加工、組立が困難になる。上限を越えて、この軸上寸法が長くなると、バックフォーカスが短くなり、ローパスフィルターや赤外カットフィルター等の光学部材の配置が困難になる。

【００１５】条件式（４）は、レンズ全系中、唯一の負レンズである第２レンズの両側の面の曲率半径の比の範囲に関し、球面収差とコマ収差を良好に補正するための条件である。第２レンズの物体側の屈折面r_3の曲率半径が小さくなるか、または像側の屈折面r_4の曲率半径が大きくなって条件式の下限を越えると、過剰の球面収差の補正ができなくなり、内方コマが大きく発生する。逆にr_3が大きくなるか、r_4が小さくなって条件式の上限を越えると、球面収差が補正不足となり、外方コマが発生し良好な結像性能が得られなくなる。

【００１６】以下、具体的な数値実施例について、本発明を説明する。以下の実施例１ないし６は、いずれも、物体側から順に、両凸の第１レンズ１０、絞Ｓ、両凹の第２レンズ２０、正の第３レンズ３０及び両凸の第４レンズ４０からなっている。第３レンズは、メニスカスレンズからなる実施例２を除いて両凸レンズからなり、いずれも、像側に強い凸面を備えている。第４レンズの後方には、実施例１ないし実施例４では、ローパスフィルター及び撮像素子のカバーガラスＣＧが配置され、実施例５及び実施例６では、撮像素子のカバーガラスＣＧのみが配置されている。カバーガラスＣＧの像側の面は撮像面である。

【００１７】［実施例１］図１及び図２は、本発明の撮影レンズ系の第１の実施例を示すもので、図１はそのレンズ構成図、図２はその諸収差図である。このレンズ系の具体的数値データを表１に示す。諸収差図中、ＳＡは球面収差、ＳＣは正弦条件、ｄ線、ｇ線、Ｃ線、それぞれの波長における、球面収差によって示される色収差、Ｓはサジタル、Ｍはメリディオナルを示している。

【００１８】表および図面中、F_{NO}はＦナンバー、Ｆは焦点距離、Ｗは半画角、f_Bはバックフォーカスを表す。Ｒは曲率半径、Ｄはレンズ厚またはレンズ間隔、N_dはｄ線の屈折率、νはｄ線のアッベ数を示す。バックフォーカスf_Bは、第４レンズ最終面（r_8面）からカバーガラスＣＧの像側面（撮像面、r_{11}）迄の距離の空気換算距離である（$f_B=d_8+(d_9/N_9)+(d_{10}/N_{10})$）。

【００１９】

【表１】

F_{NO}＝１：２．１

Ｆ＝５．２４
Ｗ＝２０．１
f_B＝３．４４

面 No.	R	D	N_d	ν_d
1	10.330	1.83	1.84666	23.9
2	-10.330	0.12	-	-
絞	∞	0.62	-	-
3	-3.894	0.91	1.92286	21.3
4	7.056	0.17	-	-
5	12.268	2.76	1.72916	54.7
6	-4.000	0.15	-	-
7	8.372	3.13	1.72916	54.7
8	-29.058	1.42	-	-
9	∞	0.99	1.45854	68.0
10	∞	2.00	1.49176	57.4
11	∞	-	-	-

【００２０】［実施例２］図３及び図４は、本発明の撮影レンズ系の第２の実施例を示すもので、図３はレンズ構成図、図４は諸収差図、表２は具体的数値データである。

【００２１】
【表２】

F_{NO}=1:2.0
F=5.24
W=19.6
f_B=2.46

面 No.	R	D	N_d	ν_d
1	5.577	2.04	1.83400	37.2
2	-20.675	0.14	-	-
絞	∞	0.89	-	-
3	-4.744	0.80	1.92286	21.3
4	6.230	0.59	-	-
5	-19.000	1.93	1.74100	52.7
6	-3.673	0.20	-	-
7	5.310	2.14	1.74100	52.7
8	-31.021	0.44	-	-
9	∞	0.99	1.45854	68.0
10	∞	2.00	1.49176	57.4
11	∞	-	-	-

【００２２】［実施例３］図５及び図６は、本発明の撮影レンズ系の第３の実施例を示すもので、図５はレンズ構成図、図６は諸収差図、表３は具体的数値データである。

【００２３】
【表３】

F_{NO}=1:2.0
F=5.24
W=20.3
f_B=3.02

面 No.	R	D	N_d	ν_d
1	11.539	4.30	1.80518	25.4
2	-14:624	0.19	-	-
絞	∞	0.64	-	-
3	-4.541	0.80	1.75084	27.7
4	4.685	0.11	-	-
5	6.341	2.53	1.56873	63.1

6	-3.483	0.15	-	-
7	5.403	2.40	1.56873	63.1
8	-14.813	1.00	-	-
9	∞	0.99	1.45854	68.0
10	∞	2.00	1.49176	57.4
11	∞	-	-	-

【００２４】［実施例４］図７及び図８は、本発明の撮影レンズ系の第４の実施例を示すもので、図７はレンズ構成図、図８は諸収差図、表４は具体的数値データである。

【００２５】

【表４】

F_{NO}=1:2.0

F=5.24

W=20.1

f_B=3.07

面 No.	R	D	N_d	ν_d
1	10.549	4.05	1.80518	25.4
2	-18.466	0.44	-	-
絞	∞	0.69	-	-
3	-4.004	0.80	1.92286	20.9
4	6.993	0.12	-	-
5	10.673	2.44	1.80400	46.6
6	-3.945	0.15	-	-
7	5.672	2.32	1.69349	50.8
8	-319.677	1.05	-	-
9	∞	0.99	1.45854	68.0
10	∞	2.00	1.49176	57.4
11	∞	-	-	-

【００２６】［実施例５］図９及び図１０は、本発明の撮影レンズ系の第５の実施例を示すもので、図９はレンズ構成図、図１０は諸収差図、表５は具体的数値データである。

【００２７】

【表５】

F_{NO}=1:2.0

F=5.24

W=20.1

f_B=1.35

面 No.	R	D	N_d	ν_d
1	8.869	4.18	1.80740	35.4
2	-15.222	0.18	-	-
絞	∞	0.63	-	-
3	-4.228	0.80	1.78470	26.2
4	4.895	0.12	-	-
5	6.635	2.36	1.64000	60.1
6	-3.531	0.15	-	-
7	5.147	4.07	1.64000	60.1
8	-100.000	0.69	-	-
9	∞	1.00	1.51633	64.1
10	∞	-	-	-

【００２８】［実施例６］図１１及び図１２は、本発明の撮影レンズ系の第６の実施例を示すもので、図１１はレンズ構成図、図１２は諸収差図、表６は具体的数値データである。

【００２９】

【表６】

F_{NO}=1:2.0

F=5.24

W=20.1
f_B=2.55

面 No.	R	D	N_d	ν_d
1	11.095	4.21	1.83400	37.2
2	-20.772	0.59	-	-
絞	∞	0.53	-	-
3	-4.069	0.80	1.69895	30.1
4	4.452	0.07	-	-
5	5.537	2.44	1.61800	63.4
6	-3.671	0.15	-	-
7	5.496	2.64	1.61800	63.4
8	-19.386	1.89	-	-
9	∞	1.00	1.51633	64.1
10	∞	-	-	-

【００３０】次に、実施例１ないし６の各条件式に対する値を表７に示す。

【表７】

	実施例１	実施例２	実施例３
条件式(1)	0.5527	0.7077	0.4655
条件式(2)	-0.3739	-0.9804	-0.3699
条件式(3)	1.5000	1.2770	1.3015
条件式(4)	0.5519	0.7615	0.9693

	実施例４	実施例５	実施例６
条件式(1)	0.9651	0.9021	0.5582
条件式(2)	-0.2968	-0.3346	-0.2378
条件式(3)	1.3273	1.5853	1.3802
条件式(4)	0.5726	0.8637	0.9140

【００３１】表７から明らかなように、実施例１ないし実施例６の数値は、条件式（１）ないし（４）を満足している。また、収差図から明らかなように、各収差も良好に補正されている。

【００３２】

【発明の効果】本発明によれば、半画角２０°程度で、口径比１：２．０程度と明るく、しかも収差補正が良好で、レンズ加工が簡単で安価にできる、固体撮像素子を利用したカメラに適した撮影レンズ系を得ることができる。

【図面の簡単な説明】

【図１】本発明による撮影レンズ系の第１の実施例のレンズ構成図である。

【図２】図１のレンズ系の諸収差図である。

【図３】本発明による撮影レンズ系の第２の実施例のレンズ構成図である。

【図４】図３のレンズ系の諸収差図である。

【図５】本発明による撮影レンズ系の第３の実施例のレンズ構成図である。

【図６】図５のレンズ系の諸収差図である。

【図７】本発明による撮影レンズ系の第４の実施例のレンズ構成図である。

【図８】図７のレンズ系の諸収差図である。

【図９】本発明による撮影レンズ系の第５の実施例のレンズ構成図である。

【図１０】図９のレンズ系の諸収差図である。

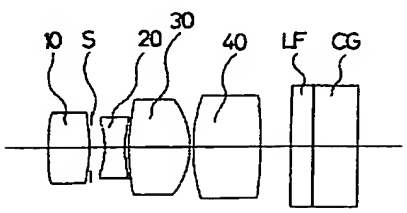
【図１１】本発明による撮影レンズ系の第６の実施例のレンズ構成図である。

【図１２】図１１のレンズ系の諸収差図である。

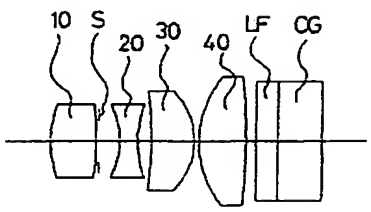
【符号の説明】

１０　第１レンズ
２０　第２レンズ
３０　第３レンズ
４０　第４レンズ
Ｓ　絞
ＬＦ　ローパスフィルター
ＣＧ　カバーガラス

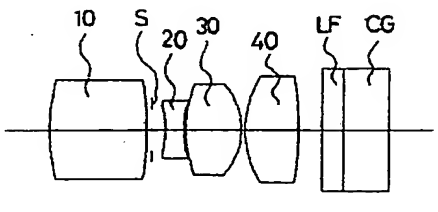
【図１】



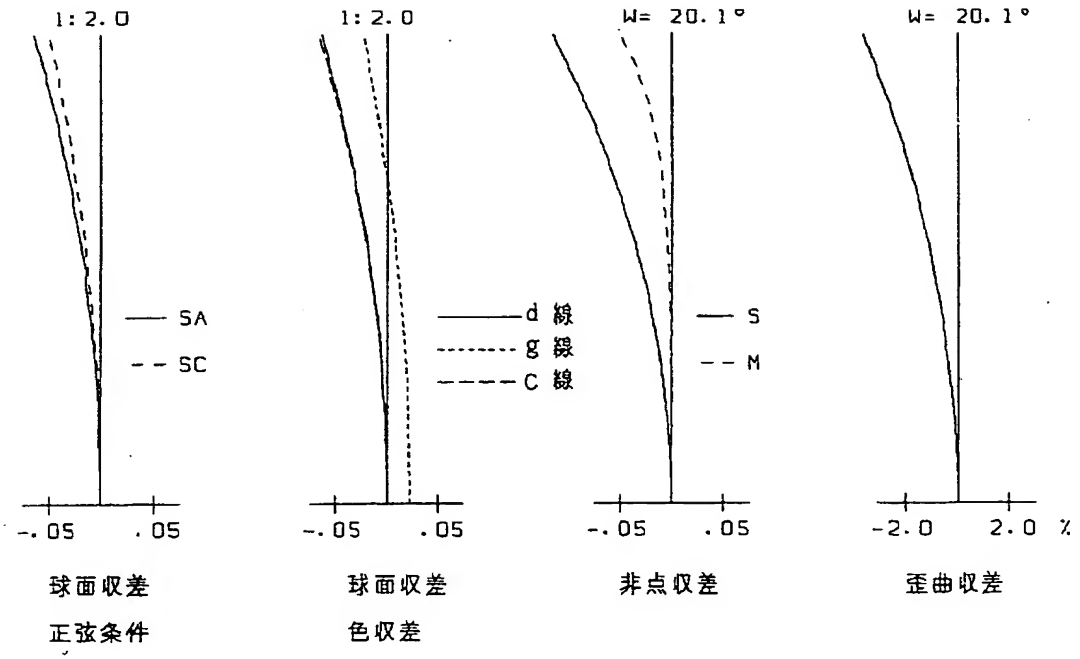
【図３】



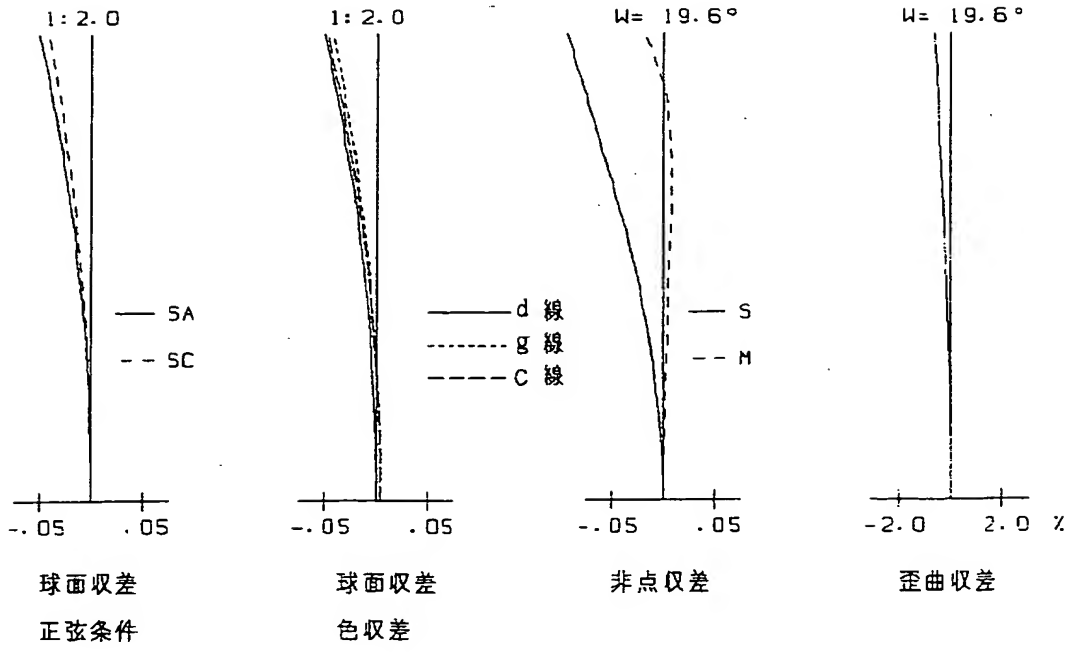
【図５】



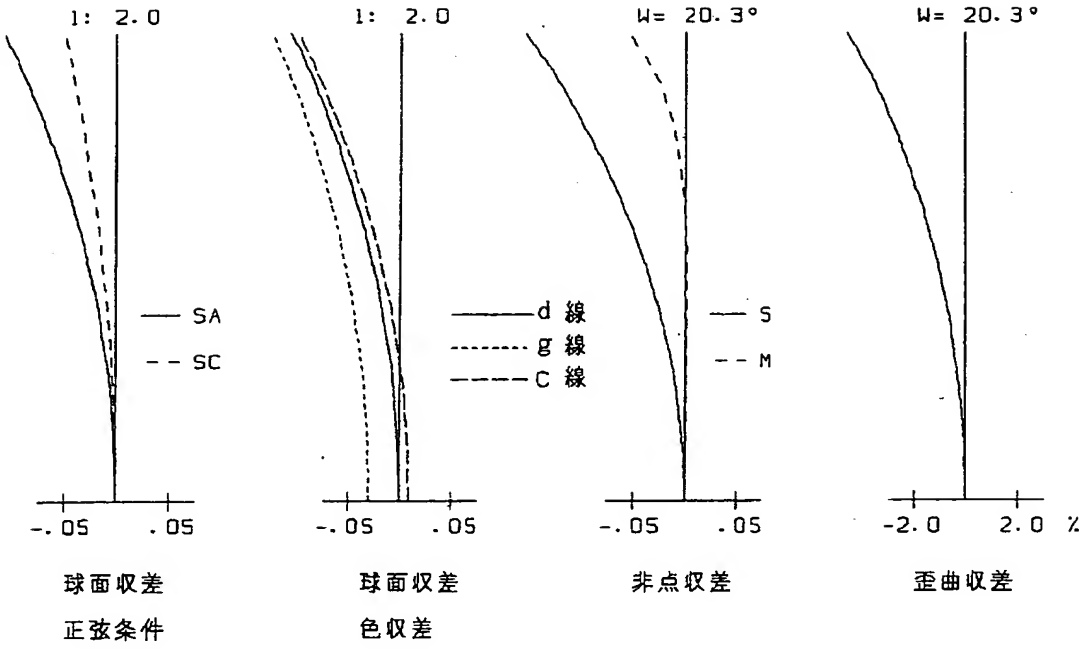
【図２】


1:2.0
SA
SC
-.05
.05
球面収差
正弦条件
1:2.0
d 線
g 線
C 線
-.05
.05
球面収差
色収差
W= 20.1°
S
M
-.05
.05
非点収差
W= 20.1°
-2.0
2.0
%
歪曲収差

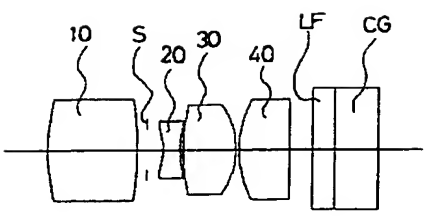
【図４】


1:2.0
SA
SC
-.05
.05
球面収差
正弦条件
1:2.0
d 線
g 線
C 線
-.05
.05
球面収差
色収差
W= 19.6°
S
M
-.05
.05
非点収差
W= 19.6°
-2.0
2.0
%
歪曲収差

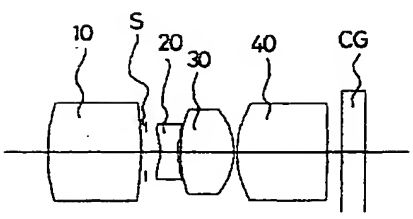
【図６】


1: 2.0
SA
SC
-.05
.05
球面収差
正弦条件
1: 2.0
d 線
g 線
C 線
-.05
.05
球面収差
色収差
W= 20.3°
S
M
-.05
.05
非点収差
W= 20.3°
-2.0
2.0 %
歪曲収差

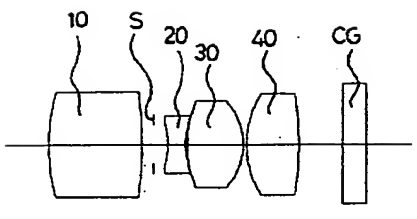
【図７】


10
S
20
30
40
LF
CG

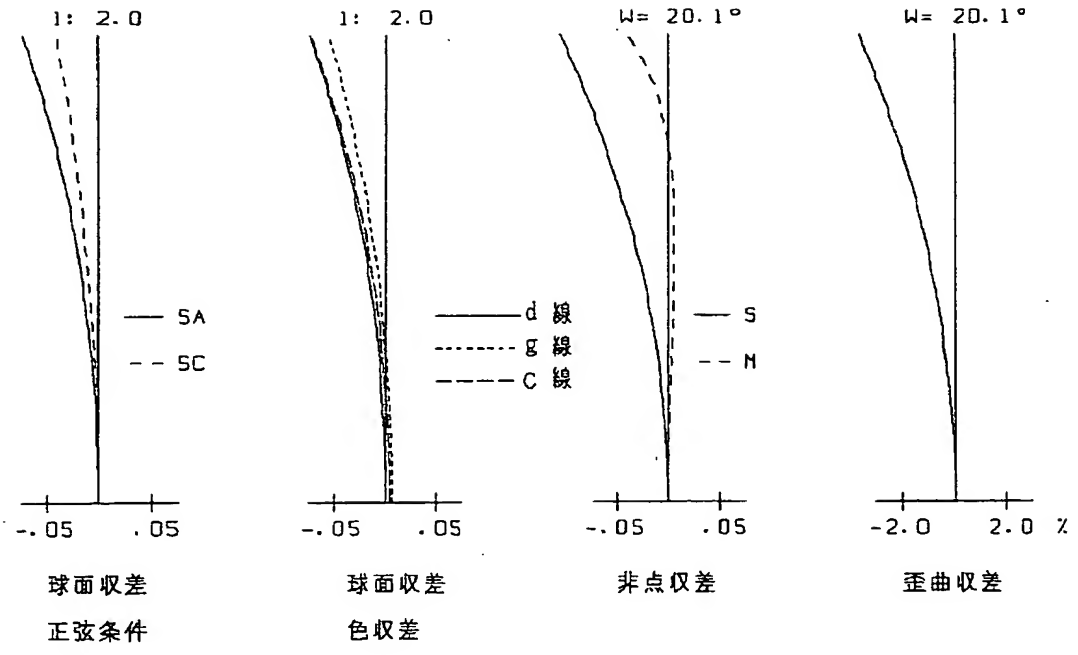
【図９】


10
S
20
30
40
CG

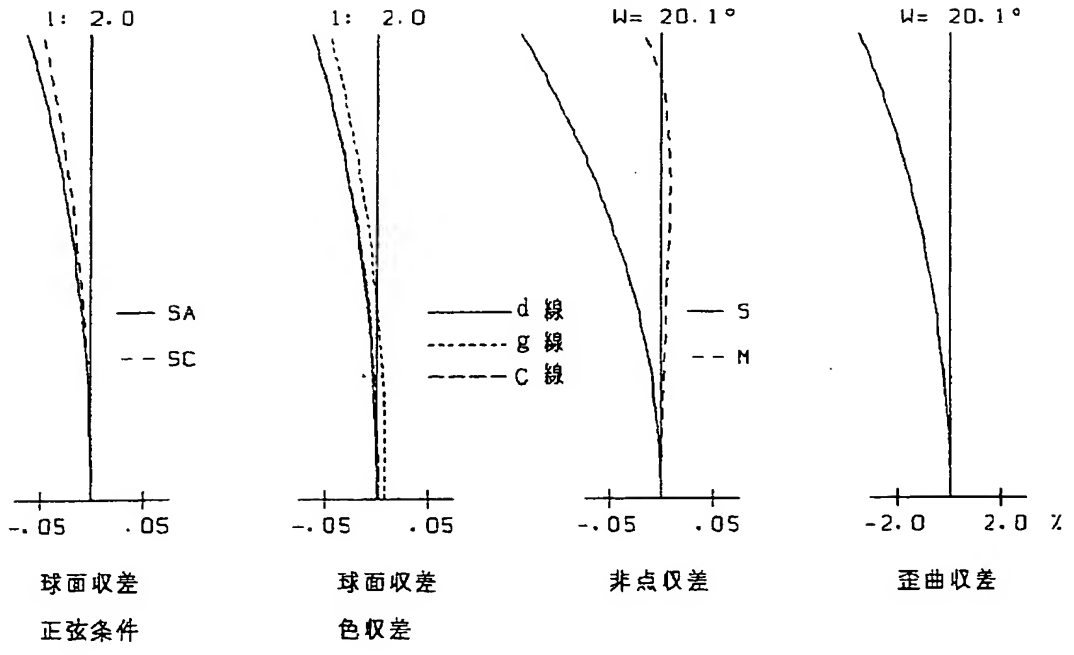
【図１１】


10
S
20
30
40
CG

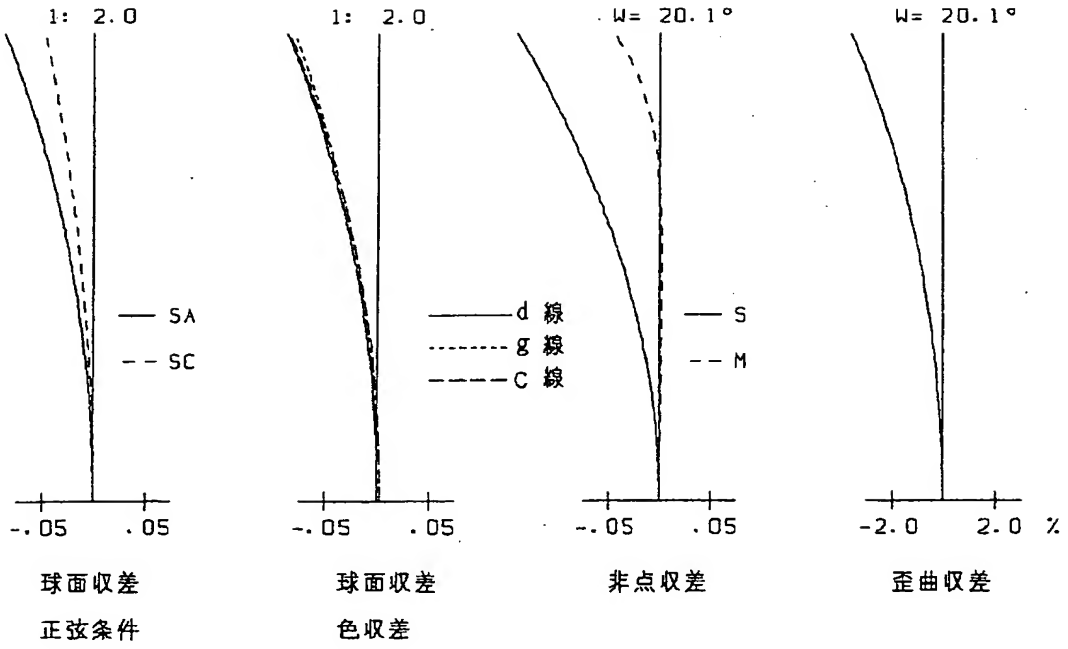
【図８】


1: 2.0
SA
SC
-.05
.05
球面収差
正弦条件
1: 2.0
d 線
g 線
C 線
-.05
.05
球面収差
色収差
W= 20.1°
S
M
-.05
.05
非点収差
W= 20.1°
-2.0
2.0 %
歪曲収差

【図１０】


1: 2.0
SA
SC
-.05
.05
球面収差
正弦条件
1: 2.0
d 線
g 線
C 線
-.05
.05
球面収差
色収差
W= 20.1°
S
M
-.05
.05
非点収差
W= 20.1°
-2.0
2.0 %
歪曲収差

【図１２】


1: 2.0
SA
SC
-.05
.05
球面収差
正弦条件
1: 2.0
d 線
g 線
C 線
-.05
.05
球面収差
色収差
W= 20.1°
S
M
-.05
.05
非点収差
W= 20.1°
-2.0
2.0
%
歪曲収差